Multi geophysical parameters for earthquake forecasting

Bapat[1] has stated that various funding agencies should come forward and support research related to earthquake prediction in order to save the lives of people. Various academic institutions as well as the Geological Survey of India have carried out field measurements in Assam over a long period and found changes in several geophysical parameters in the wake of prediction of major earthquakes of magnitude greater than 8.0. We are lucky that such a major earthquake has not occurred so far; whether it will occur in the future is difficult to predict. Similar to India, California, along the San Andreas Fault, is another vulnerable region where a major earthquake, after 1906, has been anticipated.

The US and several countries have spent millions of dollars on earthquake prediction research. While some scientists strongly believe that earthquakes cannot be predicted, some believe otherwise. The subject of earthquake prediction is debated, with little funding available in the US for research. However, scientists from several countries, including India are making efforts to find a reliable precursor for an impending earthquake.

Earthquake is a complex process as the Earth's structure is complex; subsurface configuration and inhomogeneities differ from location to location. Understanding of earthquake process is a complex system of systems. Furthermore, earthquakes can occur in the ocean, land and coastal regions, and such complex environments make the understanding of earthquake process more challenging.

In the last few decades, several efforts have been made to study the complexity of the Earth and various parameters from the epicentral regions using ground, meteorological stations and satellite observations. All these observations have strong coupling among land–ocean–atmosphere–ionosphere associated with earthquakes[2–4]. Scientists have found that some parameters change prior to earthquakes. Though thousands of research papers have been published on the subject matter, they lack long term analysis of data and detailed statistical analysis. It is clear that earthquake process may impact the atmosphere, ionosphere and ground parameters, but the question is whether we can integrate all these parameters and predict an impending earthquake. All these parameters from land surface, *in situ*, emission of greenhouse gases, meteorological and ionospheric, must show complementary behaviour if they are associated with earthquakes.

Earthquake prediction research based on a single parameter should be discouraged; an integrated approach to combine all the parameters is a welcome proposition. The Ministry of Earth Sciences, Government of India has established few multi parametric geophysical observatories[5] in the seismic-prone areas. All the measured parameters should be examined and if complementary behaviour of the parameters is found, confidence can be gained about an impending earthquake.

It is important to know the highly seismic-prone areas so that people living there become aware of the earthquake risk and follow seismic codes to design buildings, like in Japan, which are not affected by major earthquakes. Thousands of people were killed and buildings were damaged during the following major earthquakes (magnitudes greater than 6 and 7) – Bihar–Nepal earthquake (1988), Uttarkashi (1991), Latur (1993), Jabalpur (1997), Chamoli (1999) and Bhuj (2001) in India.

As stated by Bapat[1], if we want to save lives and property, we must try to teach the population at large that earthquakes are bound to occur and it is 'impossible' to avoid earthquake. At the same time we can take lesson from the Japanese and follow proper seismic codes to design buildings in the seismic-prone regions. Such practice can save lives and property associated with an earthquake.

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Soil acidification: a recent issue in Arunachal Pradesh, Eastern Himalaya

Soil acidification – the net production of protons in the soil, is a result of various biological, chemical and plant processes such as cation/anion uptake, mineralization of soil organic matter, nitrification, dissociation of organic acids, and oxidation/reduction processes[1]. It occurs gradually in undisturbed ecosystems, but can be accelerated by intensive agriculture. It may also be enhanced by the nitrogenous fertilizers, particularly through drip irrigation systems, or the fixation of atmospheric nitrogen using leguminous plants. Change in nutrient cycles also causes soil acidification.

Three types of major land-use patterns in East Siang district (lat. 27°30′–29°20′ and long. 94°42′–95°35′), Arunachal Pradesh were studied. Among the three soils types, higher soil pH was recorded in areas with natural vegetation, while pH was found to be low in vegetable cultivated land which is common in Arunachal Pradesh (Table 1). Different agricultural practices such as slash-and-burn agriculture on hill slopes and settled cultivation in the foothills and valleys

Table 1. Comparison of soil pH under forest and agricultural land-use patterns

Land-use patterns	Depth (cm)	pH/Season			
		Monsoon	Autumn	Winter	Spring
Forest area	0–15	5.58 ± 0.10	5.96 ± 0.14	6.23 ± 0.14	5.9 ± 0.36
	15–30	5.62 ± 0.22	5.98 ± 0.04	6.16 ± 0.08	5.88 ± 0.16
Maize agroecosystem	0–15	5.22 ± 0.07	5.16 ± 0.04	5.96 ± 0.06	5.48 ± 0.61
	15–30	5.20 ± 0.05	5.15 ± 0.04	5.96 ± 0.06	5.40 ± 0.23
Vegetable agroecosystem	0–15	4.37 ± 0.10	4.78 ± 0.07	5.02 ± 0.04	4.80 ± 0.17
	15–30	4.17 ± 0.14	4.9 ± 0.05	5.1 ± 0.07	4.75 ± 0.20

± SE, standard error (n = 5).

were common in the state. These systems are being managed under low to no-input conditions. However, conventional farming has also been introduced in some areas, where chemical fertilizers and pesticides are used for better crop productivity. Chemical fertilizers such as urea, ammonium nitrate and DAP minimize the soil pH. However, organic manure of different compositions used in cultivated lands may also influence the range of soil pH. Low soil pH might also be due to the penetration and percolation of surface material to the subsurface soil depths due to heavy rain during monsoons[2]. Leaching and run-off losses of nitrates and cations such as Ca, Mg and K from the soil surface further minimize the soil pH. These lead to the acidification of soil in the hilly agricultural landscapes of Eastern Himalaya.

In the humid tropics, soil acidification often leads to severe problems in the maintenance of slash-and-burn agricultural fields which are usually seen in Arunachal Pradesh. In acidic soils, the availability of some nutrients (Ca, Mg, Mo) decreases, while others (Mn, Al) may become more readily available. Microbial activity also declines in acidic condition resulting in a significant decline in agricultural production and inhibits the effect of fertilizers. As the soil becomes more acidic, fewer agricultural plants grow. Low agro-diversity in some areas of Arunachal Pradesh is due to low pH. Day-by-day total area under permanent and intensive cultivation has been increasing and these productive farming systems with higher nitrogen use, and rotation of grain and pasture legumes for higher yield escalate the rate of soil acidification. Therefore, growers should conduct regular soil tests to monitor vineyard soils to ensure that the use of nitrogenous fertilizers or any leguminous crop does not lead to soil acidification.

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